Responsible Design Engineering & Innovation

GCE Advanced Level suggested subject content

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Contents

Content for Responsible Design Engineering & Innovation

Introduction

1. The A Level subject content sets out the knowledge, understanding, expertise and educational outcomes common to all specifications in A Level Responsible Design Engineering & Innovation (RDE&I)

2. RDE&I should focus on contexts grounded in societal responsibility as the purpose of design and engineering practice, where knowledge and understanding of material science is applied to the practical process of prototyping in the context of solving real world challenges drawn from contemporary thematic areas, such as the United Nations Sustainable Development goals.

3. The A Level specifications in RDE&I should use the core content from the four core strands of learning:
   - Design process
   - Material Science
   - Digital and physical prototyping
   - Responsibilities

4. The A level specifications in RDE&I should enable students to understand and apply design, systems, circular, futures and interdisciplinary thinking approaches through which students can **empathize** with users, **define** problems, **ideate** creatively, **prototype** solutions and **test** these for viability. Students should be able to solve contemporary problems by designing and making prototypes. A Level specifications should also provide opportunities for students to apply knowledge from other disciplines, including mathematics, science, art and design, computing and humanities, to solving technical real world challenges.

5. Students should take every opportunity to integrate and apply their understanding and knowledge from other subject areas studied during Key Stage 4, with a particular focus on science and mathematics, and the level 3 qualifications students are studying alongside RDE&I.

Aims and Objectives

6. A Level RDE&I specifications must enable students to design and to prototype in response to a design challenge, and apply specialist knowledge, understanding and practical expertise, in order to:

   - develop the intellectual awareness, mindsets and behaviors of designers and engineers working to solve complex and technical problems
   - utilize through designing and making, advancing digital and automated manufacturing technologies
   - analyze and react to contemporary real-world case studies and contexts of design, engineering and technological activity in the UK and globally
   - develop empathic intelligence, enhancing students' emotional engagement to designing for people or the environment, with commitment and persistence to solving complex problems
   - develop through practical experience effective connections with experts, develop cross-disciplinary relationships, seek out collaborations, intuit solutions and apply capabilities outside of the classroom environment
   - develop in-depth knowledge and application of the methodologies for design, systems and circular thinking, moving beyond KS4 and expanding into futures and interdisciplinary thinking, to realise more complex and innovative solutions.
   - take life centric approaches that seek out diverse perspectives and opportunities, with the growing metacognition of how design can meet the needs of more than just single users or groups
   - develop an in-depth knowledge and understanding of the material science behind existing and emerging technologies.
   - explore ways to combine materials with components and manipulate them through processes, in order to test prototypes and project how solutions will work outside of controlled environments and simulations
   - approach on real challenges that will positively impact society and its interdependency on the environment, moving beyond adaptation of existing products and systems

Subject Content

Design process

7. The application of design thinking that involves the use of strategies for understanding design needs and opportunities (empathize and define), visualizing and generating creative and innovative ideas (ideate), planning and creating viable solutions (prototype), analyzing and evaluating the ideas that best meet the criteria (test).

8. In order to make effective design choices, students will need a breadth of knowledge that includes understanding, analyzing and evaluating the areas of design process, approach and purpose as follows:

9. **Design Process**
    - Researching the problem area, accounting for stakeholders (people) and ecosystems (environments) through ethnographic, evaluative and participatory methods
    - Methods to generate, identify, prioritize, select, elicit, combine, and evaluate ideas as part of a design process that identifies patterns and priorities drawn from people and systems.
    - Developing creative solutions that are suitable to prototype and test, including methods for concept ideation and developing a design rationale that initiates stakeholder buy-in.
    - Learning from a wide range of both digital and physical prototypes through repeated testing and failure
    - Pitching, reporting and presenting, including the use of prototype demonstrations, to validate solutions
    - Commercial viability of solutions, including strategic planning for enablement and implementation in the real world

10. **Design Approach**
    - Design thinking as the approach for fostering effective and collaborative design
    - Systems thinking as the approach to designing solutions for problems and opportunities that are the sum of many interconnected parts
    - Circular thinking as the approach of designing solutions that focus on eliminating waste and pollution, circulating products and materials within the economy, and regenerating nature.
    - Futures thinking as the approach of designing based on data and research that predicts changes to society in the future.

- Interdisciplinary thinking as the approach of designing in multi-disciplined, multi sector teams and cross-sector stakeholder groups
- How to design, develop and implement research tools tailored to different design approaches and stakeholders
- The approach to designing products out of a system e.g. Design using Circular Design principles

11. **Design Purpose**
    - The values and purpose of design and engineering industries within the UK economy and globally
    - Designing for different users including: Consumers, Citizens, Communities, Inhabitants, both through inclusive design principles and when designing for exceptional people
    - The impact of design and engineering in society including the history of design and engineering, and the importance of embedded sustainable and inclusive design practice.
    - Psychology in design and engineering including anthropometrics, emotion, behaviour, wellbeing, and psychology models.

12. Students should use the knowledge and understanding listed above to develop, demonstrate and apply practical expertise when designing and producing prototypes, including where appropriate, technical prototypes. In addition, A Level specifications in RDE&I must require students to demonstrate:

    - The behaviors of successful British and International designers and engineers.
    - The ability to identify and articulate leadership and followership within the design and engineering sectors
    - Experience of collaborative research and data handling, consolidation, and the priorities of GDPR and digital security.
    - Designing for real world contexts beyond local settings
    - The features and characteristics of designing physical and digital, technologically appropriate outcomes

Material Science

13. The expertise to make informed decisions about materials and understand that materials are subject to ongoing changes in availability, processing methods, price, and that new materials are constantly being developed. In order to make effective design and engineering choices in relation to materials, students will need in-depth domain knowledge that covers:

- Material applications - Understanding of the disadvantages and advantages of a range of materials relevant to:
  - Physical prototyping applications including foams, sheet materials, textiles, natural and man-made stock forms, resins, construction kits, programmable microcontrollers and both materials suitable for additive and subtractive manufacture.
  - Digital prototyping applications including high performance composites, smart and modern materials, and new or emerging material innovations.

- Material classifications – Develop the decision-making hierarchy for selecting materials for application in different contexts by accounting for their properties and characteristics including:
  - Classification (e.g. physical, chemical, structure and defects)
  - Properties (e.g. mechanical, thermal, electrical, magnetic, optical)
  - Sourcing & extraction
  - Longevity global reserves
  - Footprint
  - Embodied energy, carbon, and water

Digital & physical prototyping

14. The material domain knowledge and practical expertise applied to digital, physical and roleplay prototyping to create a solution for testing, capable of validating ideas and identifying further refinement. In order to make effective design and engineering choices in relation to prototyping, students will need in depth knowledge that includes the understanding of:

- The purpose of prototyping – for testing, learning and communication
- Different methods for digital communication and prototyping - e.g. computer aided design, low and no code platforms, and tools for mapping systems.
- Digital devices to create and test solutions in a digital environment e.g. – simulation, performance reports, AR and VR.

- Different methods for physical communication and prototyping - e.g. sketching, rough models, functional and proof-of-principle prototypes, and systems prototyping.
- The advanced knowledge of additive and subtractive manufacturing, casting, molding, forming, machining, joining and coating.
- Using data and mathematical models to simulate and predict performance, including behavioral and attitudinal tools.

15. In addition, when designing and producing prototypes, students should also apply knowledge of roleplay and human enacted prototyping, using the knowledge above to develop, demonstrate and apply practical expertise in their designing and prototyping to create solutions based in real world contexts.

Responsibility

16. Learning about global challenges, such as those represented within the United Nations Sustainability Development goals or in the context of the planetary boundaries. In order to make effective design and engineering choices that prioritizes responsibility and societal needs, students will develop a breadth of contemporary knowledge that includes:

- Global frameworks (e.g. the SDGs), legislation, regulation, measures and agreements, and the contemporary case studies of system resilience and adaptation.
- The relationship between design, engineering and commercial business in the context of the UK economy, contemporary sustainable initiatives, negative externalities and social impact.
- Developing the understanding of the planetary boundaries in relation to human impact for futures thinking.
- The science of sustainability, key sectors for green growth, carbon net zero and regenerative principles and biomimicry.
- How circular & regenerative economies, in practice, provide opportunities for innovation in areas of waste, energy use and services.
- Circular business models, systems mapping and the scope of influence.
- Methods for eliminating waste and pollution through circular and systems thinking, through products, systems, supply chains and value creation.
- Analysing and critiquing existing impactful products and systems including; Fashion; Energy; Transport; Food; Housing; and Carbon footprint.

Contextual Challenges

17. For A Levelspecifications in RDE&I, the application of design should be set within responsible and societal contexts, that draw from local contexts to translate or scale into regional, national or global perspectives.

    An example list of contexts using the UN SDGs would be:

UN Sustainable Development Goal: Thematic Areas	
Economy	i) Work with growth of the economy ii) Industry, innovation, and infrastructure iii) Responsible consumption and production iv) Reduced Inequalities
Society	i) Poverty ii) Hunger iii) Gender Equality iv) Quality education
Climate Action	i) Good health and wellbeing ii) Affordable and clean energy iii) Peace, Justice and strong institutions iv) Sustainable cities and communities
Biosphere	i) Life on land ii) Life below water iii) Clean water and sanitation

An example list of contexts using the planetary boundaries would be:

Planetary Boundary Thematic Areas
1) ozone depletion 2) loss of biosphere 3) chemical pollution 4) climate change 5) ocean acidification 6) freshwater consumption 7) land systems 8) nitrogen and phosphorus flows in the biosphere 9) atmospheric aerosol loading.

18. For Non Examined Assessment (NEA), A Level specifications in RDE&I must require students to complete two assignments set by the Awarding organization.
    - The first should require students to apply and demonstrate their knowledge and understanding developed across the course to designing solutions without the constraints of making physical outcomes, assessed through an internally assessed, externally moderated digital design portfolio.
    - The second should require students to undertake a make and evaluate practical assignment under exam conditions, assessed at centre.